A PORTABLE HYPERGOLIC OXIDIZER VAPOR SENSOR FOR NASA'S SPACE SHUTTLE PROGRAM

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The Space Shuttle, which will begin test flights from Kennedy Space Center in 1979, uses large quantities of hypergolic propellants. The Reaction Control Systems and Orbital Maneuvering Systems engines use monomethylhydrazine fuel and nitrogen tetroxide oxidizer. Inasmuch as the vapors of these propellants are both toxic and flammable, personnel and equipment safety requirements dictate a need to monitor their concentration wherever the propellants are used.

Nitrogen tetroxide (N_2O_4) is monitored in its vapor form as NO_2. Several techniques are available to measure NO_2 in air. In 1975, the National Institute of Occupational Safety and Health evaluated instruments designed to monitor nitrogen oxides (1). This paper will describe the design and performance characteristics of an electrochemical NO_2 sensor selected by NASA for the Space Shuttle Program.

The instrument was developed for NASA by Energetics Science, Inc., and the development is described in their final report (2).

The instrument consists of a sample pump, an electrochemical cell, and control and display electronics (Figure 1). The pump pushes the sample through the electrochemical cell where the vapors are analyzed and an output proportional to the NO_2 concentration is produced. The output is displayed on a panel meter, and is also available at a recorder jack.

The electrochemical cell is made up of a polypropylene chamber covered with teflon membrane faceplates. (Figure 2). Platinum electrodes are bonded to the faceplates, and the sensing and counter electrodes are potentiostatically controlled at -200 mV with respect to the reference electrode. The cell is filled with electrolyte, consisting of 13.5 cc of 23% solution of KOH.

Table 1 lists the manufacturer's specifications for the NO_2 sensor. Two prototype instruments were tested to these specifications by the Naval Research Laboratory (3). Zero drift was typically 0.1 ppm/8 hours for one instrument, but as much as 1.0 ppm/8 hours for the other. Random span drift was on the order of 0.7 ppm/8 hours. There was a slow, negative span drift of about 0.5 ppm over four weeks.

Response and recovery times for the NO_2 sensors are very good. Initial response is almost immediate, and 90% of a change is read within 20 seconds. Accuracy is also very good. The instrument read low by 0.02 ppm at a 0.1 ppm concentration, low by 0.2 ppm at a 1.0 ppm concentration, and low by 0.6 ppm at a 10 ppm concentration. Interference tests were run on the instrument for carbon monoxide, hydrogen, krypton, methane, aliphatic and aromatic hydrocarbons, refrigerant gases and methyl alcohol at 500-1000 ppm concentrations in air. The instrument was not subject to interference from any of these gases. A battery test was also performed, and verified that the instrument is capable of operating eight hours on fully charged batteries.

A field test of one instrument has been performed at White Sands Test Facility (4). The NO_2 sensor performed well in this test, both for monitoring at Threshold Limit Value levels (5 ppm), and leak hunting in oxidizer lines. The random zero drift proved annoying, necessitating frequent rezeroing. This was the instrument with 1 ppm/8 hour drift at NRL. It was recommended that the jewel movement panel meter be replaced with a digital readout, to avoid motion sensitivity. Calibration

was found to be easy using permeation tubes, and required only about one hour. The unit held its calibration two weeks, and probably would hold longer.

In conclusion, the NO_2 sensor is considered to be adequate for NASA's needs. There are no plans at present to change the panel meter. It is felt that improved manufacturing processes will improve the zero drift characteristics. The instrument is accurate, sensitive, and easy to use and calibrate. It should make a significant contribution to the safety and reliability of the Space Shuttle program.

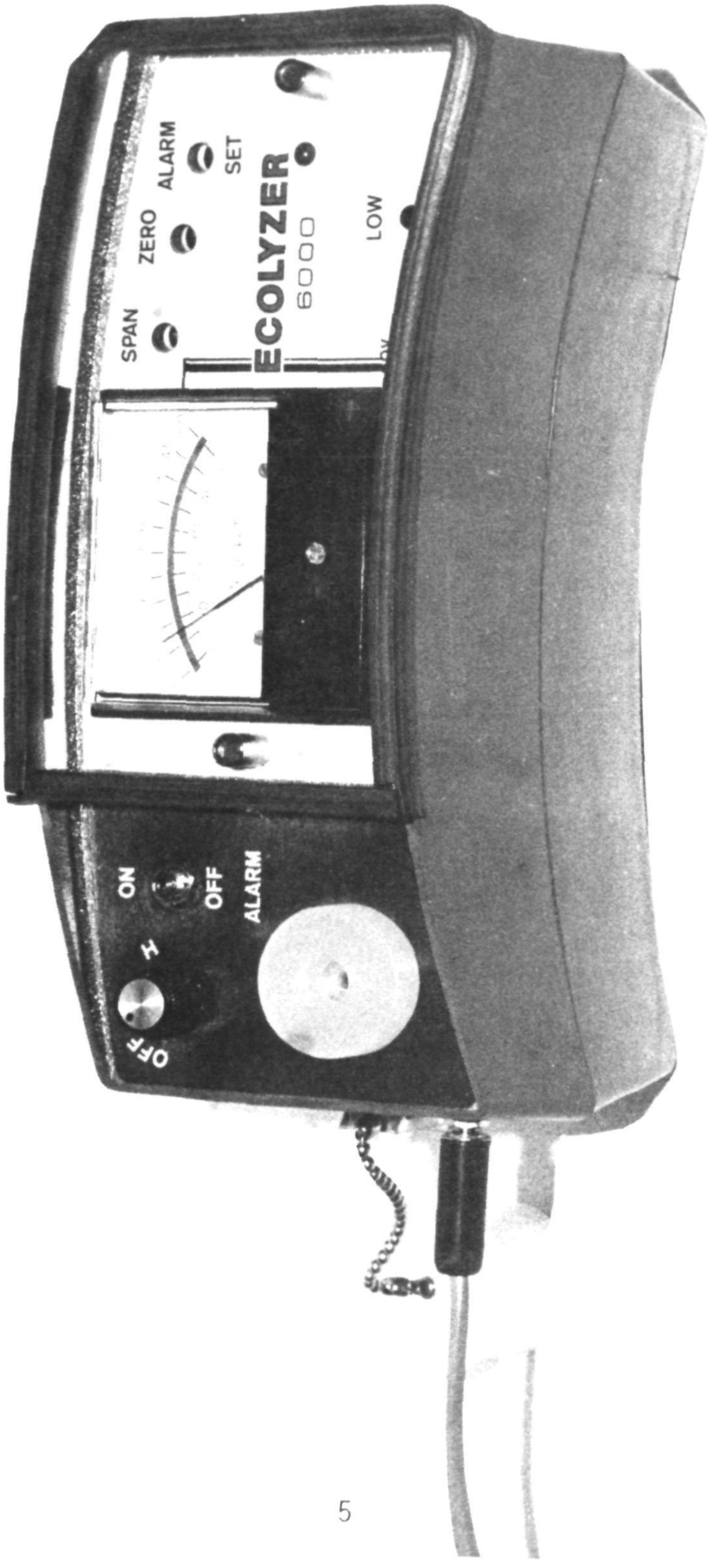
SPAN
ZERO
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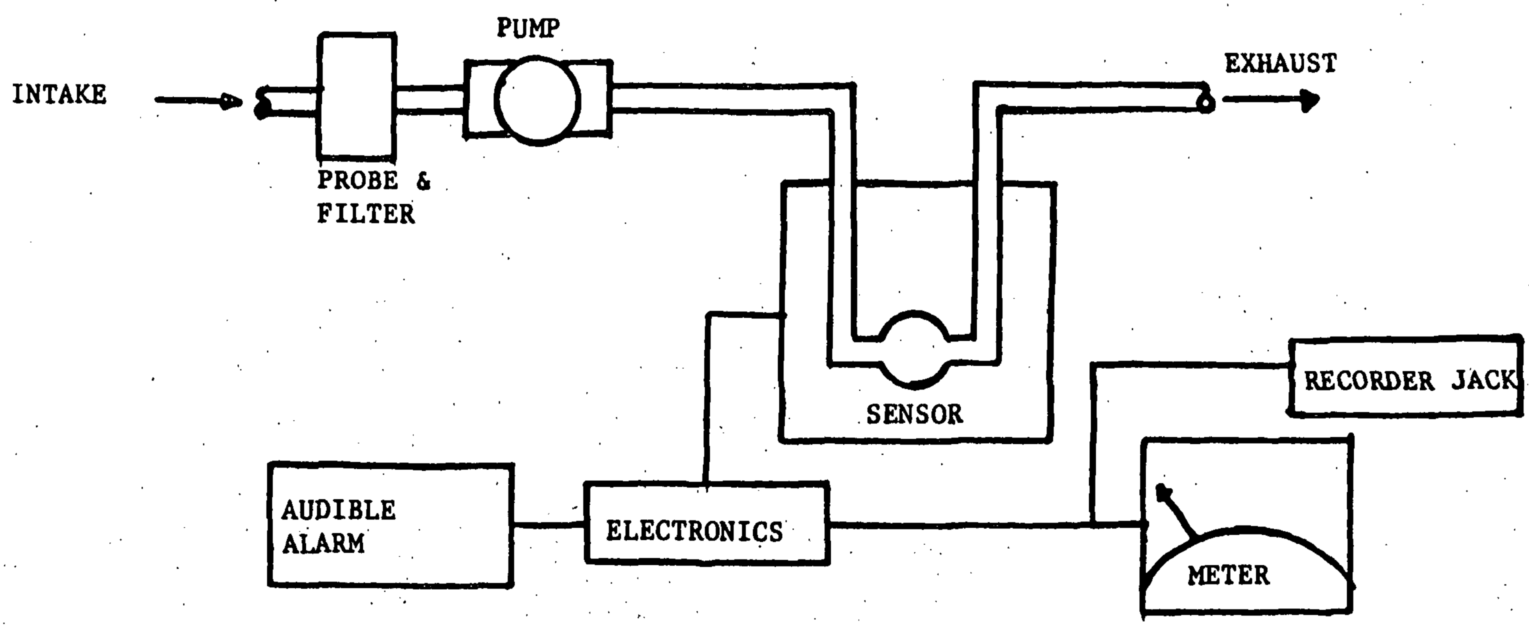
Figure 1

FLOW DIAGRAM OF THE NO_2 HIPSTER



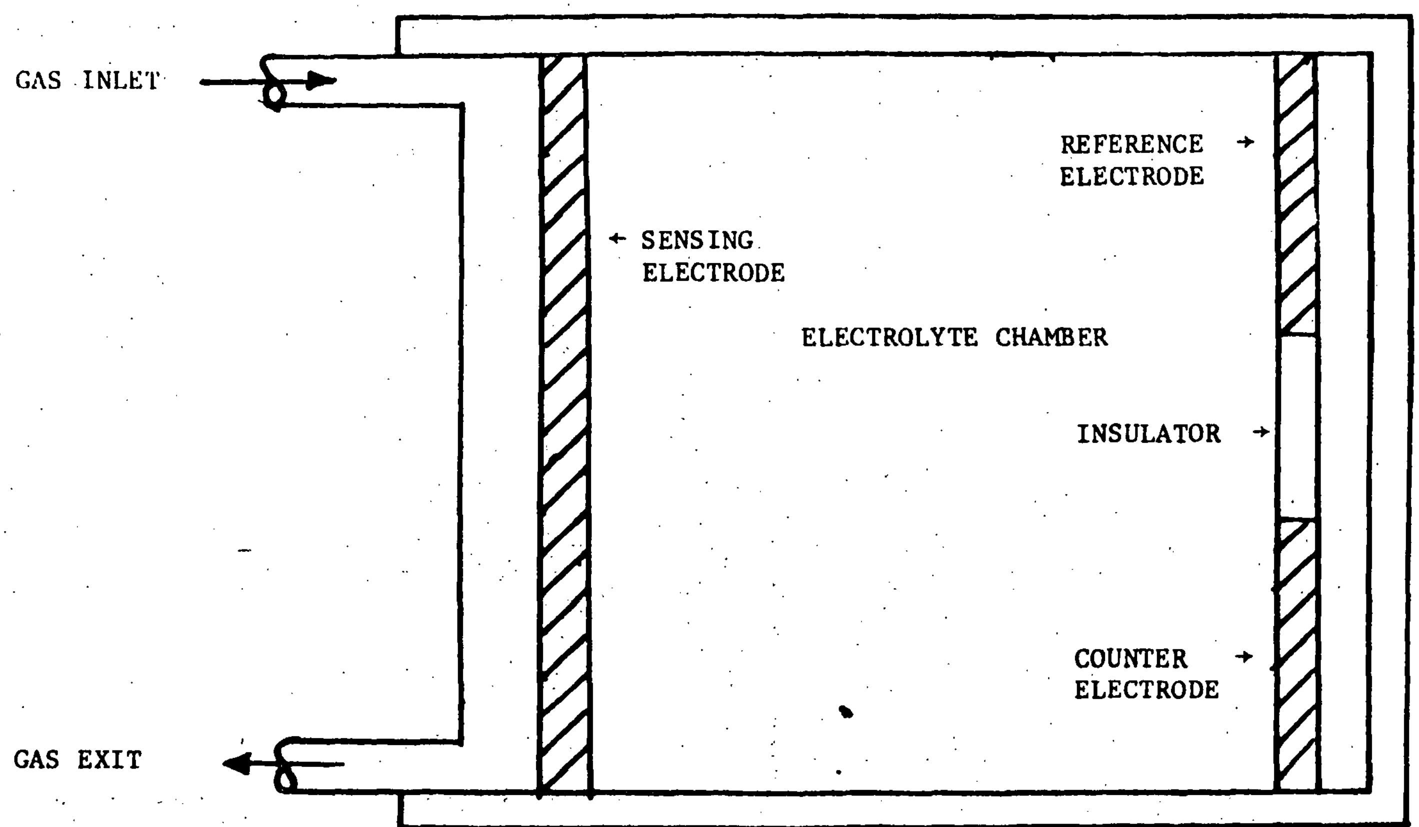


Figure 2 SCHEMATIC OF ELECTROCHEMICAL SENSOR

Table 1

INSTRUMENT SPECIFICATIONS

ITEM	MODEL 6302/NO_2 HIPSTER
Charging Power Requirements	110V to 120V AC, 50/60 Hz
Charging Time	Overnight (approx. 16 hours)
Operating Time with full charge	Eight (8) hours of continuous operation
Standby Power Consumption	No more than 48 hours between charge and use
Standard Ranges (Dual)	NO_2 0-5 ppm/0-50 ppm
Response Time	90% of signal within 30 sec.
Accuracy	± 2% of full scale range
Reproducibility	± 2% F.S.
Noise	< 1% F.S.
Stability	
Zero Drift	± 2% of full scale per day
Span or Calibration	± 2% of range per day
Operating Temperature (for full accuracy)	32°F - 104°F
Operating Relative Humidity Range	5% to 95% R.H.
Physical Dimensions	3" x 5" x 8"
Weight	3.5 lbs.

REFERENCES

1) C. D. Parker, "Evaluation of Portable, Direct-reading NO-NO_X Meters, HEW Publication No. (NIOSH) 76-161

2) J. R. Stetter and K. Tellefson, "A Study for Hypergolic Vapor Sensor Development," Final Report, NASA Contract NAS 10-8982, November 1977

3) R. A. Saunders, J. J. DeCorpo, B. J. Stammerjohn, and R. J. Kaulter, "Evaluation of an Electrochemical Detector for Trace Concentrations of Hydrazine Compounds in Air," Preliminary Final Report, NASA Contract CC-45899A, December 1977

4) P. M. Dhooge and T. J. Szydlowski, "Preliminary Report on Evaluation and Field Use of Portable Hypergolic Vapor Detectors (Hipsters), "Lockheed Electronics Co., White Sands Test Facility, N. M. March 1978